NOBANIS - Invasive Alien Species Fact Sheet

Pacifastacus leniusculus

Authors of this fact sheet:
Stein I. Johnsen, Norwegian Institute for Nature Research (NINA), Fakkelgården, NO-2624 Lillehammer, Norway; +47 73801628; stein.ivar.johnsen@nina.no

Trond Taugbøl, Glommen's and Laagen's Water Management Association, P.O.Box 1209 Skurva, NO-2605 Lillehammer, Norway; +47 93466712; tt@glb.no

Bibliographical reference – how to cite this fact sheet:
Johnsen, S.I. and Taugbøl, T. (2010): NOBANIS – Invasive Alien Species Fact Sheet – ***Pacifastacus leniusculus***. – From: Online Database of the European Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access x/x/201x.

Species description

Scientific names: *Pacifastacus leniusculus* (Dana, 1852), Astacidae.
Synonyms: no common synonyms used.
Common names: signal crayfish (GB), rak signální (CZ), signalkrebs (DK), Signalkrebs (DE), signaalvähk (EE), täplärapu (FI), žymėtasis vėžys (LT), signālvēzis (LV), Californische rivierkreeft (NL), signalkreps (NO), rak sygnałowy (PL), сигнальный рак (RU), signalkräfta (SE).

Fig. 1. *Pacifastacus leniusculus,* note the white-turquoise patch on the upper side of the claw (chelae), photo by Eilif Byrnak.

Species identification
The signal crayfish is similar to and can be confused with the noble crayfish (*Astacus* astacus) which is native to parts of the region. The signal crayfish is distinguished from the noble crayfish, both as juvenile and adult, by the more smooth nature of the chelae and the lack of a row of spines on the shoulders of carapace behind cervical groove. The white-turquoise patch on the upper side of the chelae is also unique to the adult signal crayfish (Fiskeriverket/Naturvårdsverket 2005, Lewis 2002, Pöckl *et al.* 2006).

Native range
The native range of the signal crayfish is the northwestern USA and southwestern Canada where it occurs from British Columbia in the north, central California in the south, and Utah in the east (Lewis 2002).

Alien distribution

History of introduction and geographical spread
In 1960, a small batch of signal crayfish was introduced to Sweden from California, USA, in an attempt to find a species which could replace the populations of the indigenous noble crayfish, which was severely depleted by the crayfish plague from 1907 onwards (Fiskeriverket/Naturvårdsverket 1998). The signal crayfish was considered to occupy the same ecological niche and presumed to be able to restore the recreational and commercial important crayfish fishery in the plague affected areas. The fact that it was also a carrier of crayfish plague was unknown at the time (Unestam 1972). Trials were successful and in 1967-69, a large number of signal crayfish were imported from USA and introduced into Swedish and Finnish waters (Lowery and Holdich 1988, Westman 1995). These were followed by further secondary introductions, including large numbers of domestic hatchery-reared juveniles. Further introductions, especially of juveniles from Sweden, were made to many European countries (Lowery and Holdich 1988). The signal crayfish is at present most established in Sweden where it occurs in approximately 4000 localities (Edsman and Schröder 2009). An increasing number of signal crayfish introductions have taken place during the last 30 years in Denmark and this illegal practice still goes on. The crayfish has been released in many small lakes, wherefrom it has spread to a number of the larger river system on Zealand and in Jutland. In the summer 2010 it was found in coastal waters in the Danish part of the Baltic Sea as well (Eilif Byrnak, pers. comm.; Søren Berg, pers. comm..). In Austria, 2000 signal crayfish were imported in summer 1970 from California and released in several provinces. Today, the species is present in all provinces, widely distributed, particularly in the eastern provinces, and locally abundant. The crayfish was introduced to Czech Republic in 1980 from Sweden for commercial production. Until 2006, the signal crayfish was recorded in 24 European countries/regions (Souty-Grosset *et al.* 2006). Signal crayfish was recorded in Norway in 2006 (Johnsen *et al*. 2007), but this population is now most likely eradicated with chemicals (Sandodden and Johnsen 2010). However, signal crayfish was recorded in a larger watercourse in south-eastern Norway in 2008 (Johnsen and Vrålstad 2009). Records of signal crayfish in Norway, Slovakia (Maguire *et al.* 2008) and Croatia (Petrusek and Petruskova 2007) extends the list from 2006 (Souty-Grosset *et al.* 2006) to 27 European countries/regions (Holdich *et al*. 2009). This makes the signal crayfish the most widely spread alien freshwater crayfish species in Europe (Souty-Grosset *et al.* 2006, Holdich *et al*. 2009). In the Nordic-Baltic region it is found/established in all countries except Russia (nor in Iceland, Greenland and Faroe Islands where no freshwater crayfish species occur). In 2008 the first specimen was found in Estonia (Hurt and Kivistik 2009).

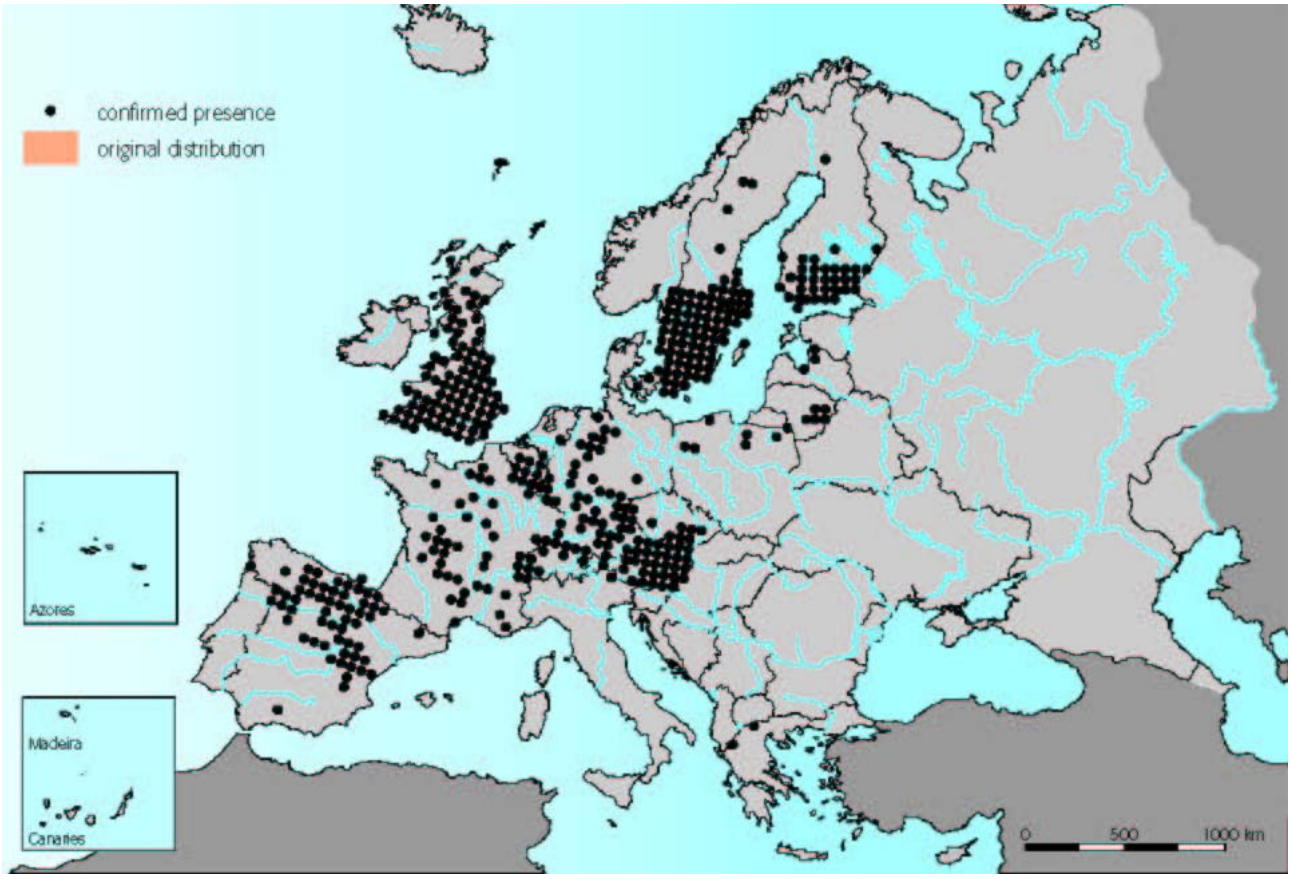

Fig. 2. Present distribution of signal crayfish (*Pacifastacus leniusculus*) in Europe. © Publications Scientifique MNHN, Paris, 2006. (After Souty-Grosset *et al.* 2006). The records of signal crayfish in Norway (Johnsen and Vrålstad 2009, Slovakia (Maguire *et al.* 2008) and Croatia (Petrusek and Petruskova 2007), Estonia (Hurt and Kivistik 2009) and Jutland, Denmark (E. Byrnak pers. comm.) are not represented in the map.

Pathways of introduction

The most common pathway of introduction into natural waters is stocking by humans. In the 1970-80s the stocking policy in the region was liberal, and the signal crayfish was introduced legally into a large number of natural waters. From the late 1980s onwards, the introduction of the signal crayfish into new areas was restricted by the environmental authorities due to the threat it posed to the indigenous, red-listed noble crayfish (Troschel and Dehus 1993, Skurdal *et al.* 1999, Edsman 2004). However, the distribution of the signal crayfish is still rapidly increasing, including more and more watercourses. The crayfish can spread by natural migration only within a watercourse, between migration barriers. Most of the current spread is therefore due to illegal introductions by humans.

Alien status in region

The signal crayfish has been introduced to all countries in the region, except Russia and the North Atlantic Islands (see table 1). In Estonia, one specimen of signal crayfish was found in R. Mustjõgi (northern Estonia) in 2008. In 2009, a bigger survey was carried out, no alien crayfish was found, but no native crayfish was found where the alien crayfish had been found previously. Thus, the signal crayfish might have been the carrier of crayfish plague (Hurt and Kivistik 2009). It is very common in Sweden and Finland, common in Germany, Denmark and Austria and found in a more limited number of localities in Poland, Lithuania and Latvia (Souty-Grosset *et al.* 2006). In Norway, signal crayfish is now only confirmed to exist in one locality (Johnsen and Vrålstad 2009).

Country	Not found	Not established	Rare	Local	Common	Very common	Not known
Austria					X		
Belgium							
Czech republic				X			
Denmark					X		
Estonia		X					
European part of Russia	X						
Finland						X	
Faroe Islands	X						
Germany					X		
Greenland	X						
Iceland	X						
Ireland		X					
Latvia			X				
Lithuania				X			
Netherlands				X			
Norway			X				
Poland				X			
Slovakia							
Sweden						X	

Table 1. The frequency and establishment of *Pacifastacus leniusculus*, please refer also to the information provided for this species at www.nobanis.org/search.asp. Legend for this table: **Not found** –The species is not found in the country; **Not established** - The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare** - Few sites where it is found in the country; **Local** - Locally abundant, many individuals in some areas of the country; **Common** - Many sites in the country; **Very common** - Many sites and many individuals; **Not known** – No information was available.

Ecology

Habitat description

The native habitat of the signal crayfish ranges from small streams to large rivers, and lakes from the coastal to the sub-alpine regions. Signal crayfish can also survive in brackish water (Holdich *et al.* 1997). The distribution of the signal crayfish in Europe comprises the same range of habitats (Souty-Grosset *et al.* 2006).

Reproduction and life cycle

The signal crayfish has a typical life cycle of a member of the crayfish family Astacidae (Lewis 2002). Mating and egglaying occurs during autumn, mainly in October. Egg numbers usually range from 200 to 400. After egg laying the female carry the eggs under the tail until hatching. Hatching time varies greatly depending on temperature, and in natural populations it may occur from late March to the end of July. The eggs hatch into miniature crayfish that stay with the mother for three stages (two moults). In the third stage the juvenile crayfish gradually become more and more independent of the mother, adopting a solitary life. Size at maturity is usually 6-9 cm total-length (from tip of head to edge of tail-fan) at an age of 2-3 years. Estimates of survivorship to age 2 vary from 10-52%, being dependent on both abiotic and biotic factors. Competition and cannibalism can

greatly affect survival in dense populations. Maximum age and size are reported to be approx. 20 years and 16-18 cm, but such sizes are very seldom.

Dispersal and spread
Humans are the overall most important vector for dispersal and spread (see above) of the signal crayfish. Due to fisheries in natural waters in most regions where it occurs, signal crayfish are easily accessible as stocking material. Within the watercourse the signal crayfish can spread by own migration. Upstream migration rates of more than 1 km per year are reported from rivers in Finland and England. Downstream spread can be faster (Westman and Nylund 1979, Guan and Wiles 1997a, Peay and Rogers 1999). There are also indications that the signal crayfish may pass dams and waterfalls by walking on dry land (Hiley 2003). Probably this behaviour is triggered by high density or other unfavourable conditions. Normally, the crayfish would not leave the water and expose itself to great predation risk on land, but at least this shows its potential for self dispersal.

Impact

Affected habitats and indigenous organisms
The signal crayfish occupies the same ecological niche as the indigenous noble crayfish. It occurs mainly in localities previously inhabited by these species, and maintains in general the same effects on natural habitats. It is considered to be a non-burrowing species in North America, but in Europe it constructs burrows in river and lake banks (Holdich and Reeve 1991), similar to the noble crayfish. As an opportunistic polytrophic feeder it also consumes detritus and thereby plays an important role in the degradation and mineralization of dead organic matter. It may exert a significant grazing pressure on macrophytes, aquatic insects, snails, benthic fishes and amphibian larvae. Several studies indicate that signal crayfish have a stronger impact on the food web structure than the indigenous noble crayfish (Guan and Wiles 1997b, Nyström 1999, 2002 and references herein).

The most severe effect of the signal crayfish is the extermination of the noble crayfish, caused by the transmission of the crayfish plague (another invasive species) (Alderman 1997). Indigenous European crayfish species have no resistance to against this disease and experience total mortality. American crayfish species on the other hand have co-evolved with the crayfish plague and developed defence systems making them a natural host for and carrier of this parasitic disease (Unestam 1972, Evans and Edgerton 2002). Most, if not all, signal crayfish are infected by the crayfish plague. Thus, if a signal crayfish population is established in a watercourse, the crayfish plague is also established, and there is no possibility for the noble crayfish to co-exist. For this reason, the spread of signal crayfish is the most serious threat to the indigenous noble crayfish.

Genetic effects
No hybrids with other crayfish species have been reported. Signal crayfish can mate with noble crayfish, but the eggs are not fertile.

Human health effects
No human health effects have been reported, although allergies towards shellfish may occur.

Economic and societal effects (positive/negative)
In many countries in the region, especially Sweden and Finland, the signal crayfish populations support a large, commercially and recreationally important, fishery (Ackefors 1999). In Europe as a whole, a total of 355 tonnes of signal crayfish was estimated from capture fisheries in 1994

(Ackefors 1998). This level has increased considerably, and in 2001 the Swedish catch was estimated to 1200 tonnes. In recent years, however, levels have dropped for unknown reasons. Viruses in combination with a chronic plague infection have been suspected as a possible reason (Söderhäll 2004). The amount of cultured amount of signal crayfish in Sweden was estimated to 42 tonnes in 1996 (Ackefors 1998).

The most serious negative effect of the signal crayfish is the extermination of the indigenous noble crayfish, due to the uncontrolled spread of the signal crayfish to more and more watercourses. The noble crayfish has great sociocultural/-economic traditions in the region (Swahn 2004) and is more valuable than the signal crayfish, also from the pure economic point of view. First and foremost because of the uncontrolled spread of signal crayfish, the noble crayfish is recognized as a threatened species included in the international Red List, the Bern Convention and EU's Habitat Directive.

Management approaches

Prevention methods
Preventing the further introduction of signal crayfish to new water bodies by humans is the greatest management challenge (for efforts, see below). In most countries in the region the introduction of live non-indigenous crayfish species, like the signal crayfish, is not permitted (Skurdal *et al.* 1999). In Latvia the import of live crayfish is allowed, only a veterinary certificate is needed (Arens and Taugbøl 2005). In all countries stocking of live crayfish in natural waters requires permission from the authorities. The lack of effective control and enforcement is, however, a problem.

Eradication, control and monitoring efforts
When the signal crayfish is established in a water body there is no practical way of eradication, except perhaps in very small, enclosed waterbodies where insecticides or other chemicals might be applied (Sandodden and Johnsen 2010). Extensive trapping may reduce population density and slow down the speed at which it spreads naturally, but it is not an effective control method. There is important research into pheromone trapping of male signal crayfish (Stebbing *et al*. 2004, Stebbing *et al*. 2005), this method could become in the future be used as a control and eradication method. Monitoring of the distribution and identifying new populations by test-fishing provide important information necessary in a management strategy. Monitoring of crayfish distribution and occurrence takes place in several countries in the region and reveals that illegal signal crayfish introductions occur to a large extent and is the major reason for further spread.

Information and awareness
The key factor to prevent further spread of the signal crayfish is information about the negative effects. It is imperative to convince landowners/fishermen that the indigenous noble crayfish is the best alternative for crayfish harvest. With live signal crayfish easily accessible from natural waters not far away, it is impossible to prevent (illegal) stocking if local people want to do so. Information campaigns, including folders/brochures, media contact and education in schools are important. Likewise concrete projects aimed at conservation and sustainable use of noble crayfish and the prevention of further spread of signal crayfish, through information and involvement of relevant interest groups. The so-called "Astacus"-project, an inter-regional collaboration project between Norway and Sweden, is an example of such a project (www.astacus.org).

Knowledge and research
Several research topics have been carried out on the signal crayfish in the region, especially in Sweden and Finland. Prevalent topics are on its ecology, immunology, behaviour, population biology and environmental impact (see Nyström 1999, 2002, Söderhäll and Söderhäll 2002 and references herein). There has also been some research into improving methods for its culture.

Recommendations or comments from experts and local communities
Signal crayfish should be managed as a valuable resource for recreational and commercial fishery in areas where it is established (Ackefors 1999, Taugbøl and Skurdal 1999). In other areas where the noble crayfish still has a chance to survive, the great values of this species should be emphasized, and it should be made clear to all stakeholders that the spread of signal crayfish to these areas is a tragedy to nature and to the socioeconomic/-cultural values the noble crayfish represents. In addition it is an environmental crime.

Furthermore, in the light of decreasing catches and numerous collapses of signal crayfish populations in recent years, there is no guarantee that stocking of signal crayfish will give a harvestable population in the long run.

References and other resources

Contact persons
Lennart Edsman (SE) Swedish Board of Fisheries, Freshwater Laboratory, Stångholmsvägen 2, SE-178 93 Drottningholm, Sweden; Phone: + 46 8-699 06 00, Fax: +46 8-699 06 50**;** E-mail: Lennart.Edsman@fiskeriverket.se

Stein I. Johnsen (NO) Norwegian Institute for Nature Research, Fakkelgaarden, NO-2624 Lillehammer, Norway; Phone: +47 73801628; E-mail: stein.ivar.johnsen@nina.no

Stefan Nehring (DE) Federal Agency for Nature Conservation, Konstantinstrasse 110, D-53179 Bonn; Phone: +49-228-84911444; E-mail: stefan.nehring@bfn.de

Eilif Byrnak (DK) Natur and Miljø, Vestsjællands Amt, Alleen 15, DK-4180 Sorø; Denmark Phone: +45 57872829; E-mail: eby@vestamt.dk

Gudni Gudbergsson (IS) Institute of Freshwater Fisheries, Vagnhofdi 7, IS-110 Reykjavik, Iceland; Phone: +354 5676400; E-mail: gudni.gudbergsson@veidimal.is

Augusts Arens (LV) Latvian Crayfish and Fish Farmers' Association, 7-6 Alberta St., Riga LV-1010, Latvia; Phone/fax: +371-7-336-005; E-mail: earens@latnet.lv

Przemyslaw Smietana (PL) University of Szczecin, Department of Ecology, ul. Waska 13, PL-71-412 Szczecin, Poland; E-mail: leptosp@univ.szczecin.pl

Margo Hurt (EE) Department of Fishery, Estonian University of Life Sciences, Krutzwaldi 48, EE-51006 Tartu, Estonia; Phone: + 372 731 3481; E-mail: margo.hurt@emu.ee

Ari Mannonen(FI) Crayfish Innovation Center, Päijänne-Institute, Koulutuskeskus Salpaus, Laurellintie 55, FI-17320 Asikkala, Finland; Phone: +358 40 7082524; E-mail: raputietokeskus@jippii.fi

Links

The International Association of Astacology (IAA)

Global Invasive Species Data Base - *Pacifastacus leniusculus* (ISSG - Invasive Species Specialist Group)

References

Ackefors, H. 1998. The culture and capture crayfish fisheries in Europe. World Aquaculture 29: 12-24, 64-67.

Ackefors, H. 1999. The positive effects of established crayfish introductions in Europe, in: Gherardi, F. and Holdich, D. M. (Eds), *Crayfish in Europe as alien species. How to make the best of a bad situation*. A. A. Balkema, Rotterdam: 49-61.

Alderman, D.J. 1997. History of the spread of crayfish plague in Europe, in: *Crustaceans: Bacterial and fungal diseasaes.* QIE Scientific and Technical Review 15: 15-23.

Arens, A. and Taugbøl, T. 2005. Status of freshwater crayfish in Latvia. Bulletin Français de la Pêche et de la Pisciculture (376-377): 519-528.

Edsman, L. 2004. – The Swedish story about import of live crayfish. Bulletin Français de la Pêche et de la Pisciculture (372-373): 281-288.

Edsman L. and Schröder S. 2009. Åtgärdsprogram för Flodkräfta 2008–2013 (Astacus astacus), Fiskerivertet och Naturvårdsverket, Rap. 5955, 67 p.

Evans L. H. and Edgerton B. F. 2002. – Pathogens, parasites and commensals, in Holdich D. M. (Ed.), *Biology of freshwater crayfish*. Blackwell Science, Oxford: 377-438.

Fiskeriverket/Naturvårdsverket 1998. Åtgärdsprogram för bevarande av flodkräfta.

Fiskeriverket/Naturvårdsverket 2005. Information folder. Web-version

Guan, R-Z. and Wiles, P.R. 1997a. The home range of signal crayfish in a British lowland river. Freshwater Forum 8: 45-54.

Guan, R.-Z. and Wiles, P.R. 1997b. Ecological impact of introduced crayfish on benthic fishes in a British lowland river. Conservation Biology 11: 641-647.

Hiley, P.D. 2003. The slow quiet invasion of signal crayfish (*Pacifastacus leniusculus*) in England – prospects for the white-clawed crayfish (*Austropotamobius pallipes*). Pp. 127-138 in: Holdich, D.M. and Sibley, P.J. (eds.) *Management and Conservation of Crayfish*. Proceedings of a conference held on 7th November, 2002. Environment Agency, Bristol, 217 pp.

Holdich, D. M, Harlioglu, M. M. and Firkins, I. 1997. Salinity adaptations of crayfish in Brittish Waters with particular reference to *Austropotamobius pallipes, Astacus leptodactylus* and *Pasifastacus leniusculus*. Estuarine, Coastal and Shelf Science 44: 147-154.

Holdich, D. M., and Reeve, I. D. 1991. Alien crayfish in the British Isles. Report for the National Environment Research Council, Swindon.

Holdich, D.M., Reynolds, J.D., C. Souty-Grosset, C. and Sibley, P.J. 2009. A review of the ever increasing threat to European crayfish from non-indigenous crayfish species. Knowledge and Management of Aquatic Ecosystems 394-395, 11.

Hurt, M. and Kivistik, M. 2009 Signaalvähi ja jõevähi levik ja arvukus Jägala jõestikus. Report for the Ministry of the Environment.

Johnsen, S.I., Taugbøl, T., Andersen, O., Museth, J. and Vrålstad, T. 2007. The first record of the non-indigenous signal crayfish *Pasifastacus leniusculus* in Norway. Biological Invasions 9: 939-941.

Johnsen, S.I. and Vrålstad T., 2009. Signal crayfish and crayfish plague in the Halden watercourse – proposition for a measurement plan, NINA Report 474, 29 p.

Lewis, S.D. 2002. *Pacifastacus*, *in* Holdich D. M. (Ed.), *Biology of freshwater crayfish*. Blackwell Science, Oxford: 511-540.

Lowery R. S. and Holdich D. M. 1988. *Pacifastacus leniusculus* in North America and Europe, with details of the distribution of introduced and native crayfish species in Europe, in Holdich D. M. and Lowery R. S. (Eds), *Freshwater crayfish*: *biology, management and exploitation*. Croom Helm, London: 283-308.

Maguire I., Klobucar, G., Marcic, Z. and Zanella D., 2008. The first record of *Pacifastacus leniusculus* in Croatia. Crayfish News: IAA Newsletter, 30, 4, 4.

Nyström P. 1999. Ecological impact of introduced and native crayfish on freshwater communities: European perspectives, in Gherardi, F. and Holdich, D. M. (Eds), *Crayfish in Europe as alien species. How to make the best of a bad situation*. A. A. Balkema, Rotterdam: 63-85.

Nyström P. 2002. Ecology, *in*: Holdich, D. M. (Ed.), *Biology of freshwater crayfish*. Blackwell Science, Oxford: 192-235.

Peay, S. and Rogers, D. 1999. The peristaltic spread of signal crayfish (*Pacifastacus leniusculus*) in the River Wharfe, Yorkshire, England. Freshwater Crayfish 12: 665-676.
Petrusek A. and Petruskova T. 2007. Invasive American crayfish *Pacifastacus leniusculus* (Decapoda: Astacidae) in the Morava River (Slovakia). Biologie, Bratislava, 62(3): 356–359.
Pöckl M, Holdich DM and Pennerstorfer J (2006) Identifying native and alien crayfish species in Europe. Craynet, p 47.
Sandodden, R. and Johnsen, S. I. 2010. Eradication of introduced signal crayfish *Pasifastacus leniusculus* using the pharmaceutical BETAMAX VET.®. Aquatic Invasions 5(1): 75-81.
Skurdal J., Taugbøl T., Burba A., Edsman L., Söderbäck B., Styrishave B., Tuusti J. and Westman K. 1999. Crayfish introductions in the Nordic and Baltic countries, in Gherardi, F. and Holdich, D. M. (Eds), *Crayfish in Europe as alien species. How to make the best of a bad situation*. A. A. Balkema, Rotterdam: 193-219.
Souty-Grosset C., Holdich D.M., Noël P.Y., Reynolds J.D. and Haffner P. (eds.) 2006. Atlas of Crayfish in Europe. Muséum national d'Histoire naturelle, Paris, 187 p. (Patrimoines naturels, 64).
Stebbing, P. D., Watson, G. J., Bentley, M. G., Fraser, D., Jennings, R. Rusthonm S. P. & Sibley, P. J. 2004. Evaluation of the capacity of pheromones for control of invasive non-native crayfish: part 1. English Nature Research Report No. 578. English Nature, Peterborough: 39 p.
Stebbing, P. D., Watson, G. J., Bentley, M. G., Fraser, D., Jennings, R. & Sibley, P. J. 2005. Evaluation of the capacity of pheromones for control of invasive non-native crayfish: part 2. English Nature Research Report No. 633. English Nature, Peterborough, 46 p.
Swahn, J.-Ö. 2004. The cultural history of crayfish. Bulletin Français de la Pêche et de la Pisciculture (372-373): 243-251.
Söderhäll, I. and Söderhäll, K. 2002. Immune reactions,in: Holdich, D. M. (Ed.), *Biology of freshwater crayfish*. Blackwell Science, Oxford: 439-464.
Söderhäll, K. 2004. Krasslig kräfta – tvivelaktig import. Miljöforskning 2004-08-10.
Taugbøl T. and Skurdal J. 1999. The future of native crayfish in Europe: How to make the best of a bad situation?, in Gherardi F. and Holdich D. M. (Eds), *Crayfish in Europe as alien species. How to make the best of a bad situation*. A. A. Balkema, Rotterdam: 271-279.
Troschel, H.J. and Dehus, P. 1993. Distribution of crayfish species in the Federal Republic of Germany, with special reference to *Austropotamobius pallipes.* Freshwater Crayfish 9: 390-398.
Unestam, T. 1972. On the host range and origin of of the crayfish plague fungus. Rep. Inst. Freshw. Res. Drottningholm, 52: 192-198.
Westman K. 1995. Introduction of alien crayfish in the development of crayfish fisheries: experiences with signal crayfish (*Pacifastacus leniusculus* (Dana) in Finland and the impact on the noble crayfish (*Astacus astacus* (L.)). Freshwater Crayfish 10: 1-17.
Westman, K. and Nylund, V. 1979. Crayfish plague, *Aphanomyces astaci*, observed in the European crayfish, *Astacus astacus*, in Pihlajavesi waterway in Finland. A case study on the spread of the plague fungus. Freshwater Crayfish 4: 419-426.

Date of creation/modification of this species fact sheet: 08-11-2010